University of California, Berkeley
Physics 105 Fall 2000 Section 2 (*Strovink*)

EXAMINATION 4

Directions. Do both problems (weights are indicated). This is a closed-book closed-note exam except for four $8\frac{1}{2} \times 11$ inch sheets containing any information you wish on both sides. You are free to approach the proctor to ask questions – but he will not give hints and will be obliged to write your question and its answer on the board. Roots, circular functions, *etc.*, may be left unevaluated if you do not know them. Use a bluebook. Do not use scratch paper – otherwise you risk losing part credit. Cross out rather than erase any work that you wish the grader to ignore. Justify what you do. Box or circle your answer.

1. (50 points)
Four thin rods of length a and mass m are welded together to form a square picture frame of side a and mass $4m$. In a set of body axes tied to the frame, the frame lies in the xy plane; its corner is at the origin and its sides lie along the $\hat{x}$ and $\hat{y}$ axes. (Note that the origin does not coincide with the frame's CM.)

The frame is rotating counterclockwise about the (body or space) $\hat{y}$ axis with uniform angular velocity ω. In the body axes, what are the components of its angular momentum?

2. (50 points)
Consider a football in a force-free environment. Neglecting its seams and laces, approximate it as cylindrically symmetric about its own $\hat{3}$ (body) axis. At $t = 0$, a set of space ($'$) axes is (momentarily) coincident with the body axes. As seen in the space axes at $t = 0$, the CM of the football is at rest at the origin; the football is rotating counterclockwise about the (space) $\hat{2}'$ axis with angular velocity ω (this is "end-over-end" rotation).

Give a qualitative description of the football's motion for $t > 0$ as seen in its own (body) system. Justify your assertions. Does the football's angular momentum appear to stay constant when it is observed in the body system?